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BLAST PARAMETERS OF LEAD STYPHNATE, LEAD AZIDE, AND TETRACENE

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IIT Research Institute

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DECEMBER 1975

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This program considered three primary explosives: lead styphnate, lead azide, and tetracene. An experimental investigation was conducted to measure the peak pressures and positive impulses from explosions in systems simulating actual 1. process configurations and quantities. Variables considered included material weights, configurations, and whether or not the material was in a wet or dry condition. Peak pressure and positive impulse was measured in the scaled distance range of 3 to 40 ft/lb$^{1/3}$. TNT equivalency curves for both pressure and impulse were developed as a function of scaled range.

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IIT Research Institute (IITRI) has conducted a program to determine the TNT equivalency of lead azide, lead styphnate, and tetracene. This work was conducted for Picatinny Arsenal, Manufacturing Technology Directorate (MTD), Dover, New Jersey under Contracts DAAA21-73-C-0730 and DAAA21-74-C-0521.

Technical guidance was provided by Messrs. P. Price, D. Westover, S. Levmore, and L. Jablansky of MTD. Mason and Hanger-Silas Mason Co., Inc. personnel who contributed to the experimental program conducted at Iowa Army Ammunition Plant, Burlington, Iowa include Messrs. M. K. Jackson and J. E. Kurrle. Personnel who contributed to the experiments conducted at Dugway Proving Ground, Dugway, Utah include A. K. Keetch and P. E. Miller of the Hazards Evaluation Office.

IITRI staff who made major contributions to this effort include: M. Amor, J. Cook, C. Foxx, D. Hrdina, R. Joyce, G. Kutzer, H. Napadensky, and J. Swatosh, Jr.

Supportive data to the material presented herein is contained in a document entitled "Supportive Data for Determining the Blast Parameters of Lead Styphnate, Lead Azide, and Tetracene," IITRI Report J6317-J6342-1a.

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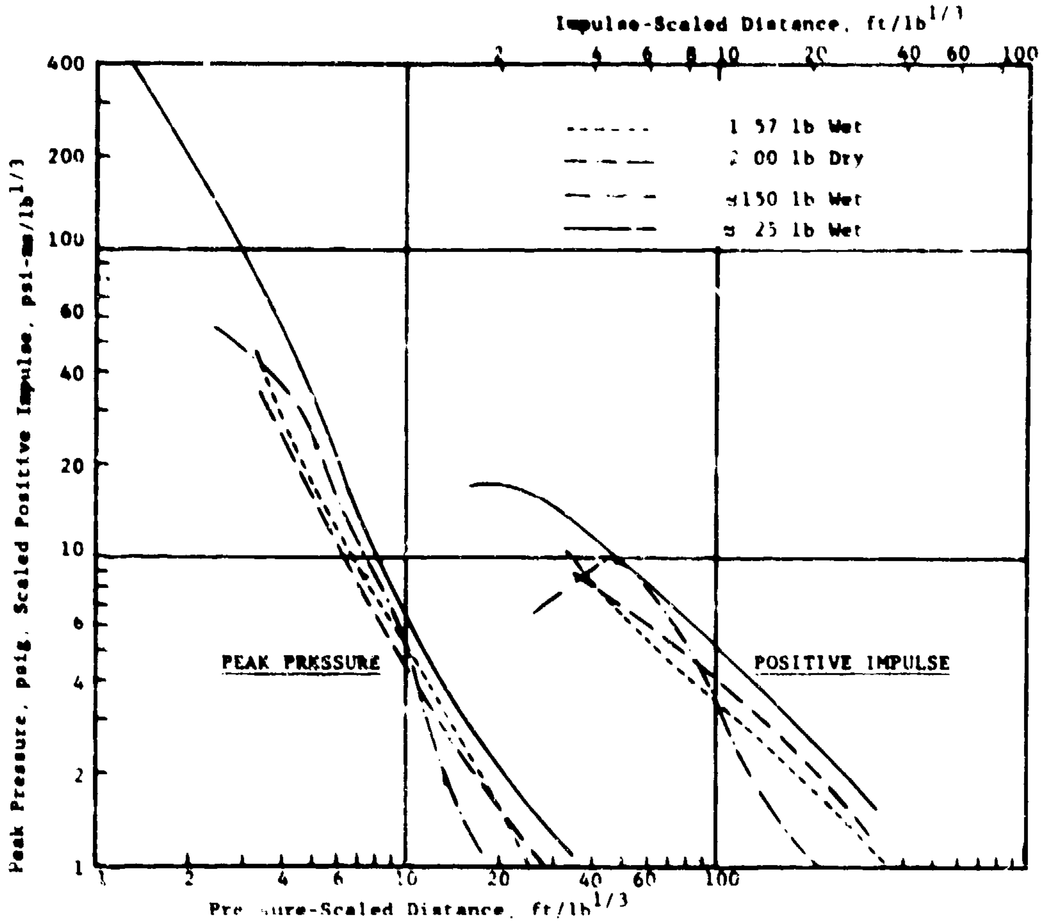
Lead styphnate was detonated in beakers (1.57 lb wet and 2.00 lb dry state), storage bags (≈ 25 lb wet), and storage/shipping drum (≈ 150 lb wet) containers. Blast output was measured and TNT equivalency was computed based upon a comparison with the explosive blast output of a surface burst of a hemispherically shaped TNT charge. The results of these computations in terms of a TNT equivalency profile are presented in the table below and in the following figures:

TNT EQUIVALENCY OF LEAD STYPHNATE

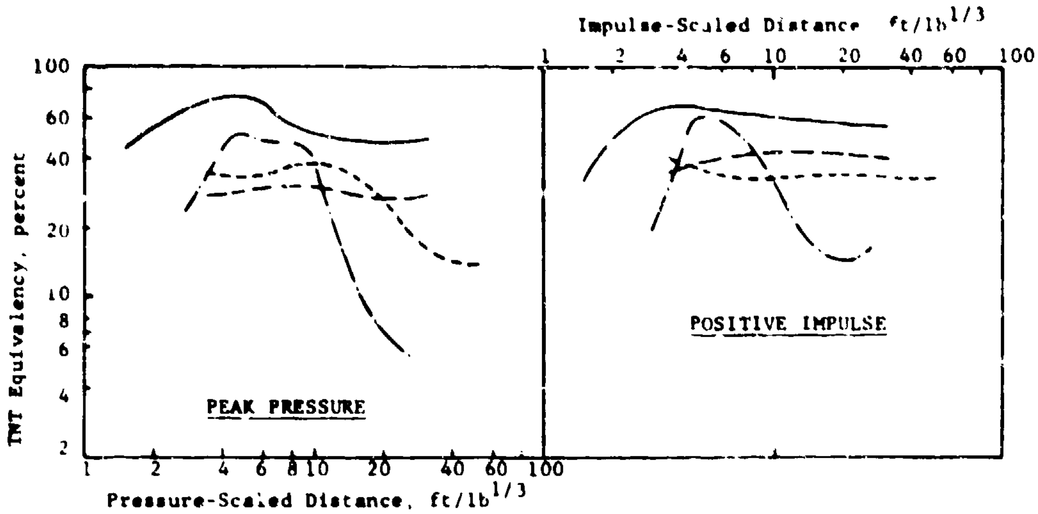
Configuration	TNT Equivalency (percent)							
	$\lambda = 3$		$\lambda = 9$		$\lambda = 18$		$\lambda = 40$	
	P	I	P	I	P	I	P	I
2.00 lb, dry, Beaker	30	30	30	40	25	40	40	40
1.57 lb, wet, Beaker	35	45	40	30	30	35	15	30
25 lb, wet, Bag	65	65	55	60	45	55	50	55
150 lb, wet* Shipping Container	30	20	45	40	8	15	-	-

Legend: λ = Scaled Distance, $ft/lb^{1/3}$
P = Peak Pressure TNT Equivalency
I = Positive Impulse TNT Equivalency

* The term "wet" in this instance refers to the explosive, submerged under a water/ethanol 50/50 solution, which is stored inside a 55 gallon metal drum. Otherwise the term "wet" means after surplus liquid has drained off.



PEAK PRESSURE AND SCALED IMPULSE - LEAD STYPHNATE



TNT EQUIVALENCY - LEAD STYPHNATE

SUMMARY - LEAD AZIDE

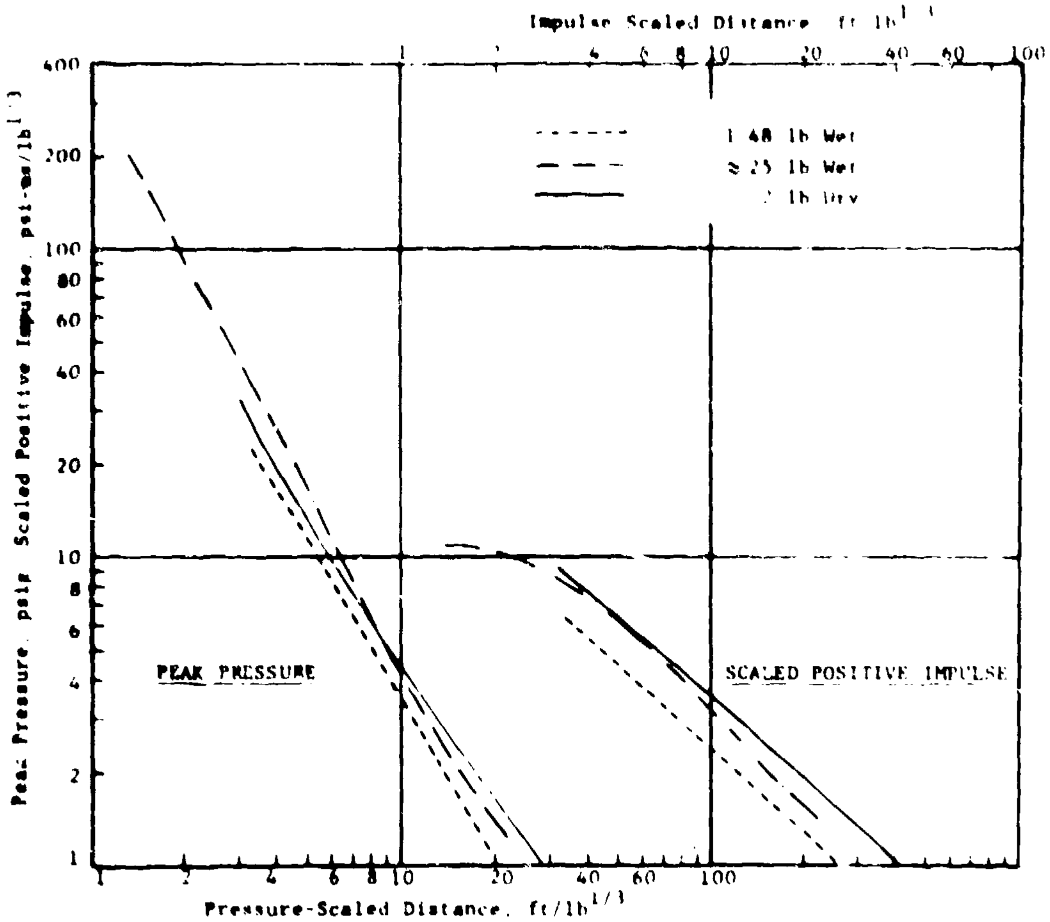
Lead Azide was detonated in beakers (1.48 lb wet and 2.00 lb dry state) and in storage bags (≈ 25 lb wet). Blast output was measured and TNT equivalency was computed based upon a comparison with the explosive blast output of a surface burst of a hemispherically shaped TNT charge. The results of these computations in terms of a TNT equivalency profile are presented in the table below and in the following figures.

TNT EQUIVALENCY OF LEAD AZIDE

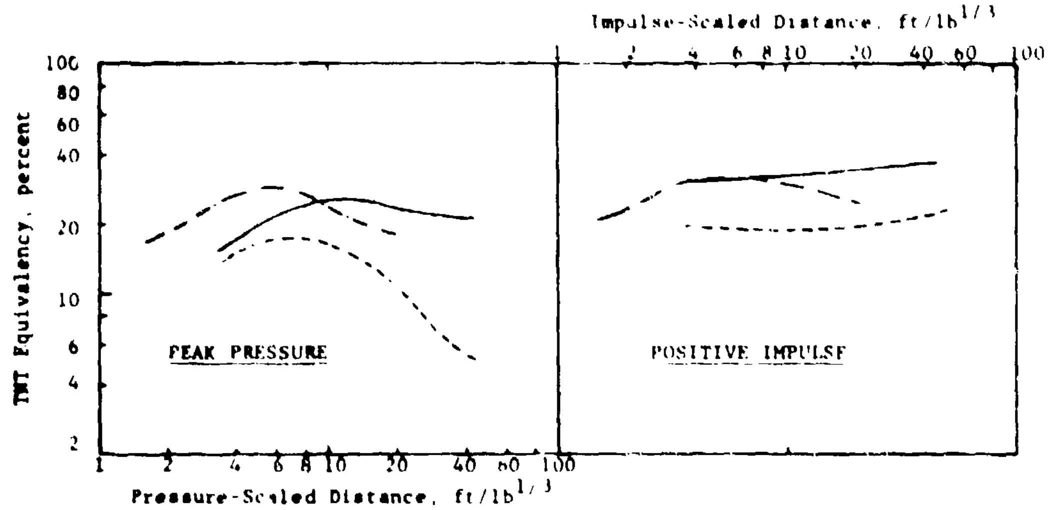
Configuration	TNT Equivalency (percent)							
	$\lambda = 3$		$\lambda = 9$		$\lambda = 18$		$\lambda = 40$	
	P	I	P	I	P	I	P	I
2.00 lb, dry, Beaker	15	30	25	30	25	35	20	35
1.48 lb, wet*, Beaker	15	20	15	20	10	20	6	20
25 lb, wet* Bag	25	30	25	30	25	35	20	35

Legend: λ = Scaled Distance, $ft/lb^{1/3}$
P = Peak Pressure TNT Equivalency
I = Positive Impulse TNT Equivalency

* The term "wet" signifies that surplus liquid (water/ethanol 50/50 solution) has drained off.



PEAK PRESSURE-SCALED IMPULSE LEAD AZIDE



TNT EQUIVALENCY - LEAD AZIDE

SUMMARY - TETRACENE

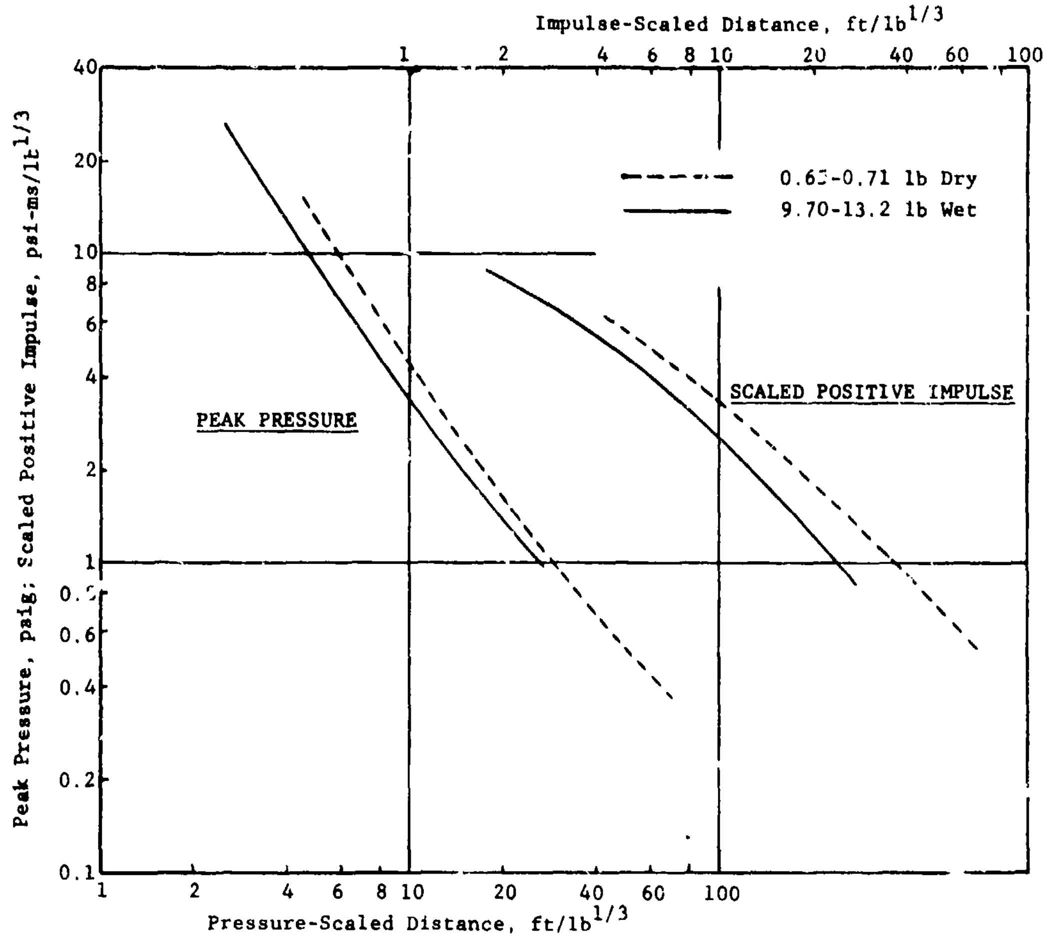
Tetracene was detonated in beakers (≈ 0.65 lb quantities, dry state) and in storage bags (≈ 10 lb quantities, wet state). All attempts to detonate wet tetracene in less than 1 lb quantities were unsuccessful. Blast output was measured and TNT equivalency was computed based upon a comparison with the explosive blast output of a surface burst of a hemispherically shaped TNT charge. The results of these computations in terms of a TNT equivalency profile are presented in the table below and in the following figures:

TNT EQUIVALENCY OF TETRACENE

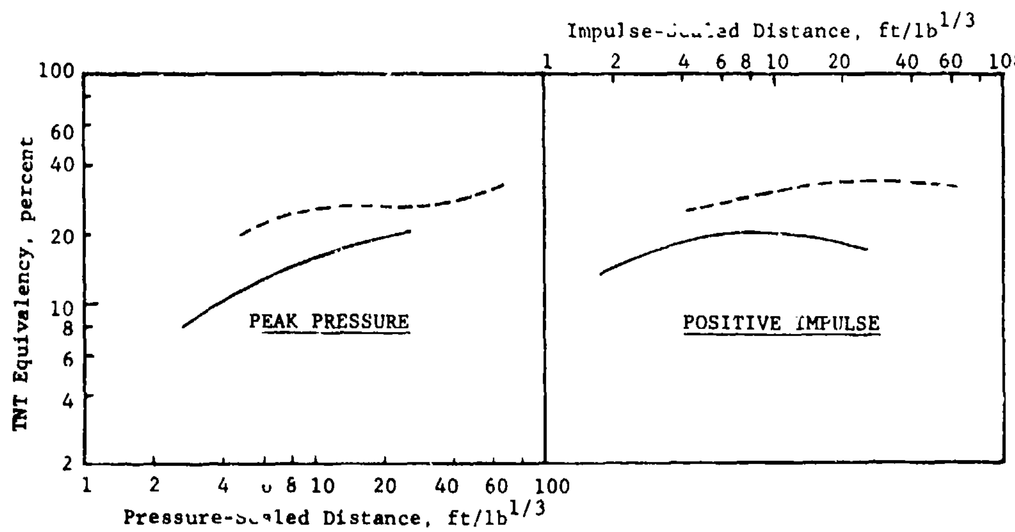
Configuration	TNT Equivalency (percent)							
	$\lambda = 3$		$\lambda = 9$		$\lambda = 18$		$\lambda = 40$	
	P	I	P	I	P	I	P	I
0.65 lb, dry, Beaker	20	25	25	30	25	35	30	35
≈ 10 lb, wet*, Bag	10	15	15	20	20	20	25	-

Legend: λ = Scaled Distance, ft/lb$^{1/3}$
P = Peak Pressure TNT Equivalency
I = Positive Impulse TNT Equivalency

* The term "wet" signifies that surplus liquid (water/ethanol 50/50 solution) has drained off.



PEAK PRESSURE-SCALED IMPULSE - TETRACENE



TNT EQUIVALENCY - TETRACENE

1. INTRODUCTION

1.1 Background

The U.S. Army Materiel Command initiated a program to upgrade the safety standards of new and existing ammunition plants. In support of this program, the Manufacturing Technology Directorate of Picatinny Arsenal developed design standards for hardening protective structures to withstand the effects of the detonation of high explosives. Design and safety engineers require data pertinent to the maximum strength of a blast wave that may originate from any of the explosive or deflagrateable materials present in the plant. Since the airblast capabilities of the three primary explosives: lead styphnate, lead azide and tetracene could not be obtained from the available literature, the Arsenal sought to establish the TNT equivalencies of these materials.

Past methods for siting and the design of individual components of explosive manufacturing and related facilities have been based on gross quantities of explosives or propellants. Present day technology has shown that cost effective yet safe facilities can be built, if design criteria is based on the actual explosive output of the materials involved.

A facility designer requires information on the blast pressure-time history, characterized by peak pressure and positive impulse. A considerable amount of prior work has been performed in establishing the airblast parameters of TNT. Consequently, for facility designs involving other energetic materials the design information can be expressed in terms of TNT equivalency. In this report information is presented for peak pressure, positive impulse, pressure TNT equivalency, and impulse TNT equivalency.

Benefits to be realized through this study include significant cost savings (by avoiding the overdesign of structures) and improved safety of personnel(by the installation of adequate blast protection).

1.2 Objectives

Experimentally determine the maximum airblast output, peak overpressure and positive impulse, of three primary explosives: lead styphnate, lead azide (RD 1333), and tetracene.

Determine the TNT equivalencies of each primary explosive by comparing its measured pressure and positive impulse with those produced by the detonation of an unconfined hemispherical charge of TNT.

Determine how the presence or absence of water and the quantity of explosive may affect the airblast output of these primary explosives.

2. TEST PROCEDURES

2.1 Test Sites

Small-scale tests were performed in a level field located in the demolition area at Iowa Army Ammunition Plant, Burlington, Iowa. A 4-inch-thick armor plate was located at ground zero (GZ). Radiating from this point were two 20-ft-wide by 100-ft-long strips, 90 deg apart, covered and leveled with a 2 to 4-inch-thick layer of sand (Figure 1).

Large-scale tests, with basic lead styphnate only, were performed at Dugway Proving Ground, Utah on a remote desert site. A schematic plan view of the test site is shown in Figure 2. Radiating from GZ were two 40-ft-wide by 500-ft-long level land areas cleared of brush.

Pressure gages were located at discrete intervals in the cleared areas of each test site. The gages were flush-mounted in steel plates which in turn were flush-mounted with the ground surface. Determination of the location of a particular gage was based on anticipated overpressures from the test material.

2.2 Test Configurations

The three basic test configurations used are schematically illustrated in Figures 3, 4, and 5. Small charges, 2 lb or less, were shot in beakers. The beakers were standard, 1 qt conductive-rubber beakers of the type normally used to transport and store the test materials. A circular hole was cut out of the bottom of the beaker to accommodate a cylindrical PBX booster. A thin cheesecloth disc was glued to the inside bottom of the beaker to prevent the test material from leaking through the hole. A wooden platform was constructed to position a number 8 blasting cap under the PBX booster and to support the booster as shown. The wooden base plate, blasting cap, and PBX booster were first positioned at GZ. The rubber beaker containing the test material was located 1 to 1-3/4 inch above GZ, depending upon the booster size.

The dry test material shots used essentially the same configuration as shown in Figure 3. Changes included a sealed cavity under the beaker, Figure 5, which housed the blasting cap and booster. A vacuum was pulled on the cavity thereby drawing air into the top of the beaker, through the material, through holes in the bottom of the beaker and into the cavity, Figure 6.

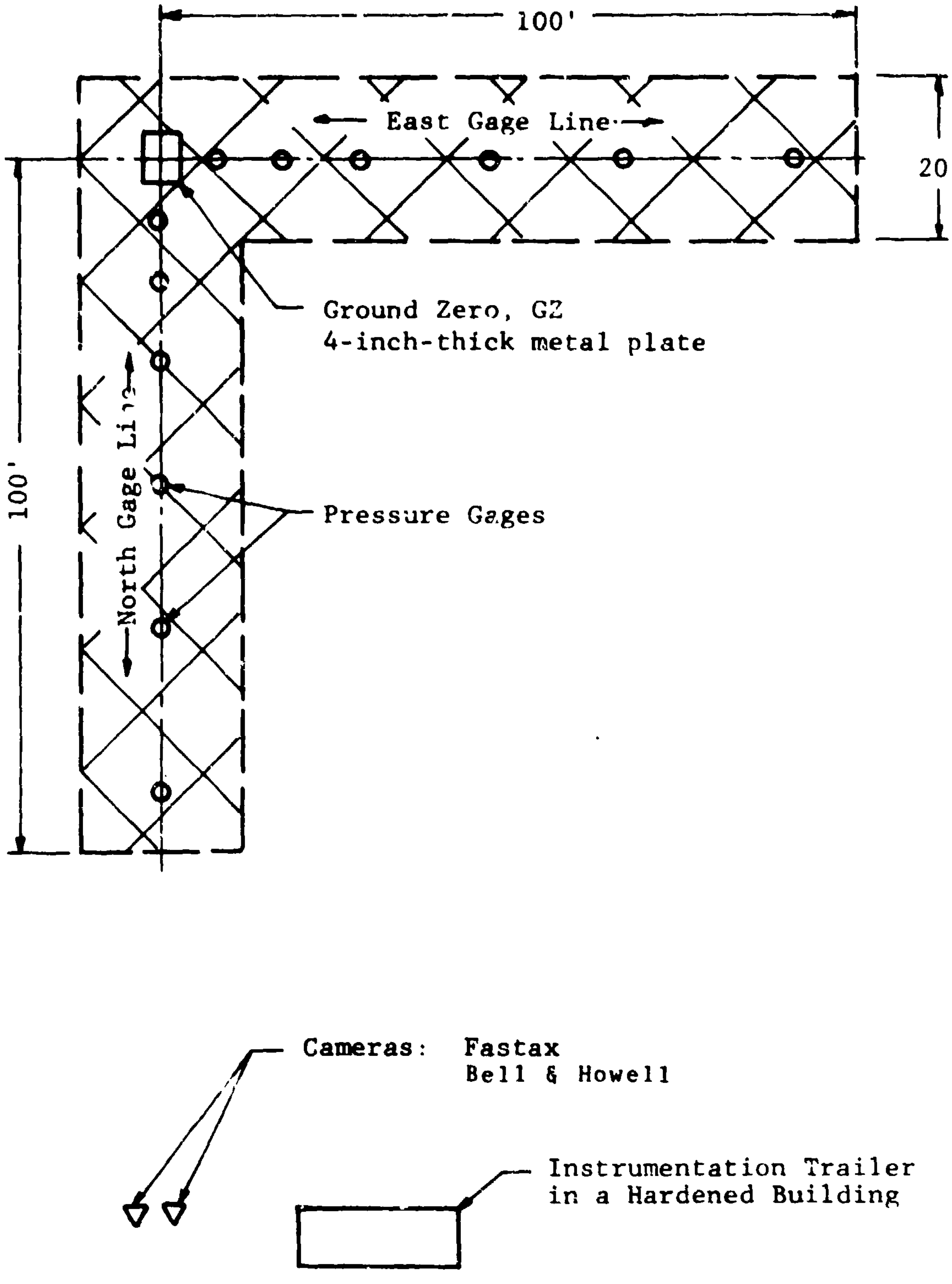


Figure 1 IAAP TEST AREA

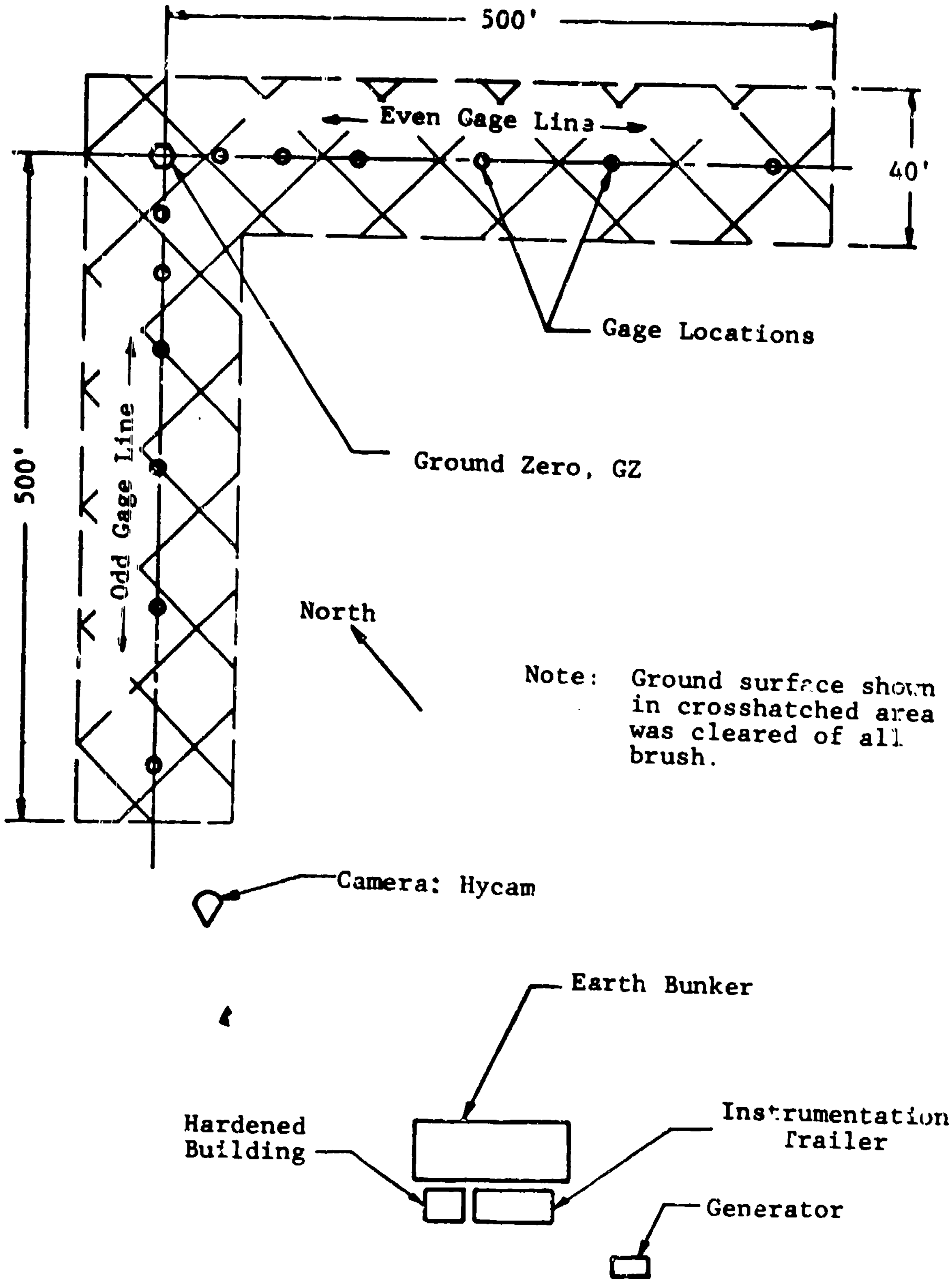


Figure 2 DPG TEST AREA

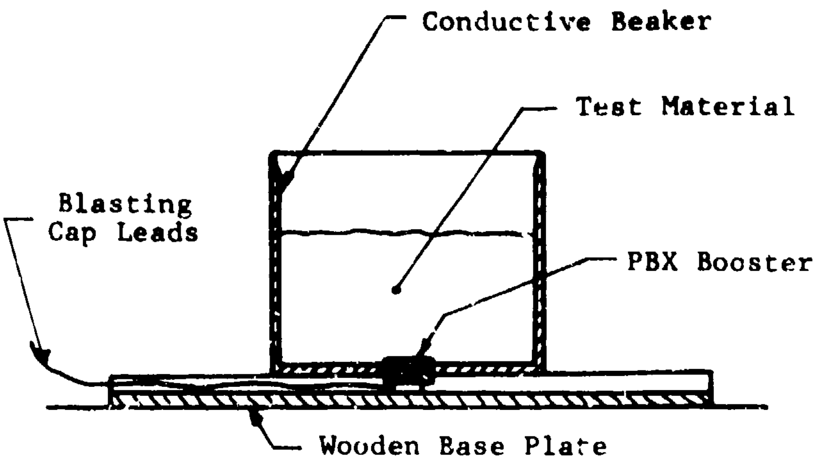


Figure 3 BEAKER TEST CONFIGURATION

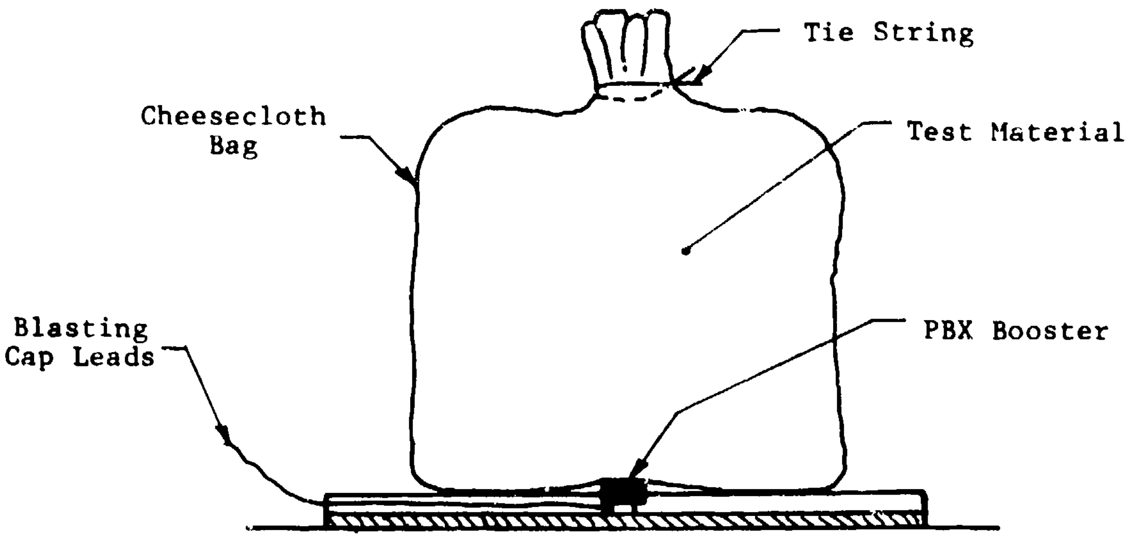


Figure 4 BAG TEST CONFIGURATION

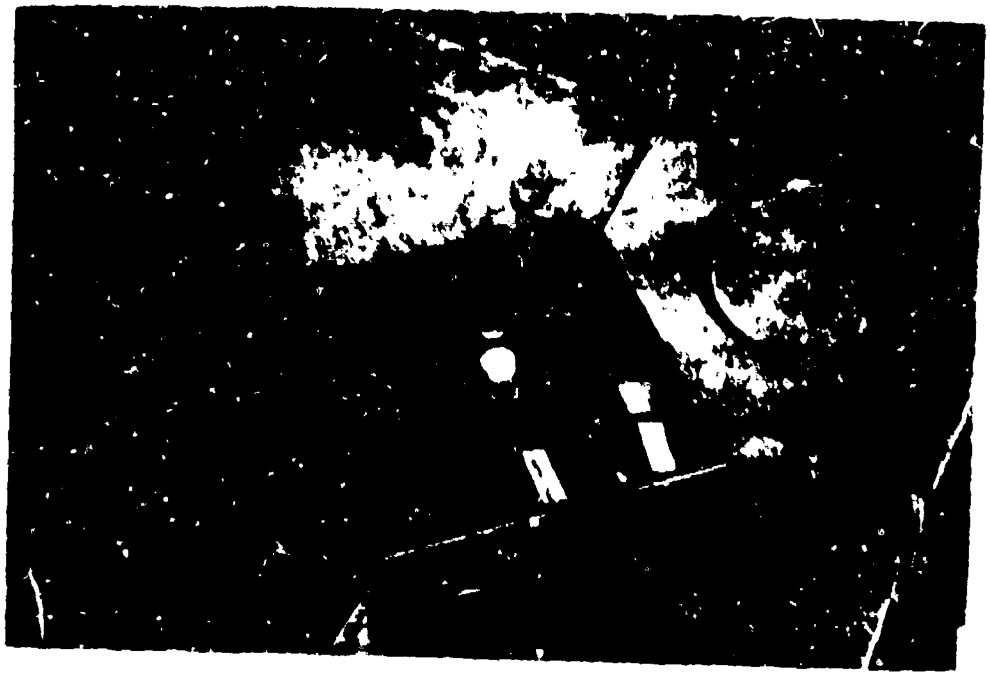


Figure 5 CAVITY UNDER BEAKER

Figure 6 BEAKER IN PLACE

Laboratory tests were conducted with this drying system and it was determined that after 8 min of aspiration the liquid content was less than 0.5 percent by weight. In the field the samples were aspirated more than 15 min before each test.

The 25 lb charge weight tests were set up as shown in Figure 4. A wooden base plate was set down on the armor plate at GZ. A wet cheesecloth bag containing the test material was set on top of the wood base plate and booster. The bag was allowed to shape itself over and around the booster. The aspect ratio of the bags was ≈ 1.

Tetracene samples were also tested in configurations* other than those illustrated in Figures 3 and 4, because difficulty was encountered in initiating that material. Test T-5 was conducted using a 0.5 lb C4** explosive booster located under the bag as shown in Figure 4. Test T-7 was conducted with a bag lying on its side and a conical 0.5 lb C4 booster on top of the bag. A wooden base plate was not used during Test T-7, the bag was placed directly on top of the armor plate. Tests T-8,9,10,11,14 and 15 were conducted with the test material in a beaker, however the PBX booster and blasting cap were located on top of the sample in the beaker. Test T-12 was conducted with the bagged test material set inside a 12 inch diameter by 11-inch-deep aluminum carrying pot. A 0.5 lb C4 booster was placed inside the pot on top of the bag as described above during Test T-7. A weighted lid was placed on top of the pot. Test T-13 was conducted with a DuPont S94 squib located inside the bag in the test material.

The 150 lb lead styphnate charges were tested in the shipping drum containers in which the material was received. Lead styphnate is also stored in these same containers. A schematic cutaway drawing of the test configuration is illustrated in Figure 7. It consisted of a 55 gal. metal drum with an airtight clamp-on lid. The lead styphnate was contained in six small bags which consisted of a cotton inner sack, a plastic liner, and a canvas outer bag. These six small bags were contained in an outer burlap bag. Sawdust was used as a filler inside the outer burlap bag. The sawdust voids between the lead styphnate bags are exaggerated in Figure 7; the small bags were in contact with one another. The 55 gal. drum was filled with an ethanol-water mix saturating the bags and lead styphnate.

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*See Table 3

**Composition C4, a plastic explosive 91 percent RDX, 2.1 percent polysobutylene, 1.6 percent motor oil, 5.3 percent di(2-ethylehexyl) sebacate.

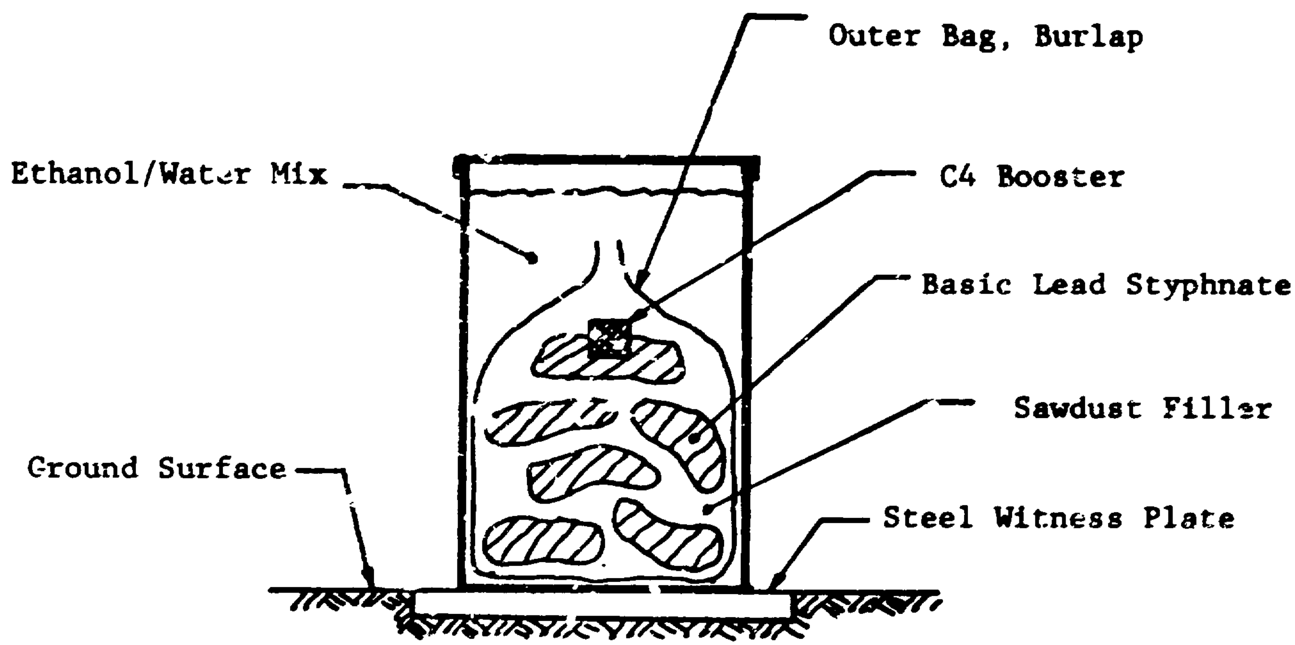

Figure 7 BASIC LEAD STYPHNATE TEST CONFIGURATION

The wet/dry weight ratio of each material was measured in the laboratory. Samples of each material were weighed in a wet state and then reweighed after drying. This wet/dry weight ratio was used to compute the dry weight of the materials that were tested in a wet state. The materials that were tested in a dry state were first dried in the laboratory, weighed, and then re-wet with water/alcohol or freon for safe transportation to the test site. These samples were then redried in the field as described above.

2.3 Verification Tests

During the course of this test program several field verification tests were performed to confirm the recording accuracy of the pressure and impulse measuring systems. They consisted of measuring the peak pressure and positive impulse from 5 to 100 lb hemispherical C4 explosive charges. The charges were set on steel witness plates at ground level. Pressure and impulse data obtained from the C4 verification shots are compared to established TNT hemispherical surface burst data (the increased energetics of C4 is accounted for). All of the gage systems used in these tests had been previously calibrated in a laboratory using accepted standards. The laboratory calibrations were used throughout the program. The verification tests indicated that the instrumentation systems were functioning properly.

The resulting pressure and impulse data points for the various scaled distances of the verification shots are plotted in Figure 8. The close groupings of the various sets of points provides a good basis of confidence in proper functioning of the blast gages. The line that passes through the "peak overpressure" gage points is a TNT pressure curve used as a standard; it was generated by Kingery, BRL 1344, 1966. The line passing through the "scaled positive impulse" points was generated by IITRI for C4. It utilizes a 1.25 factor to convert the weight of C4 to the equivalent weight of TNT. Both of these reference curves are built into the IITRI computer program. Consequently, all of the TNT equivalencies shown in this report are computed from these reference curves.

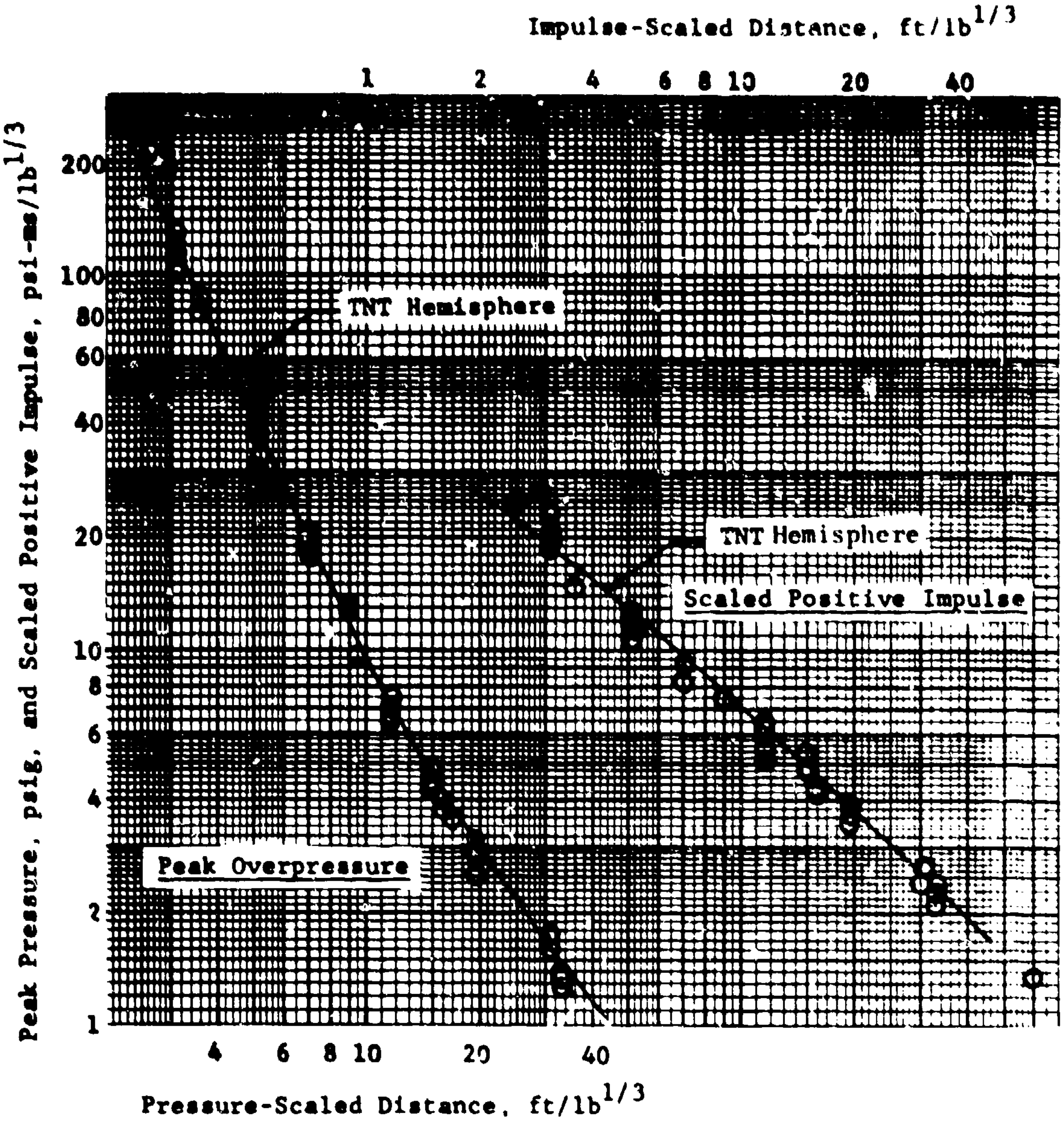

Figure 8 TNT HEMISPHERE PRESSURE AND IMPULSE CURVES

3. TEST RESULTS

3.1 General

The test results of each primary explosive material will be discussed separately in this section. The scaled distance values on all the graphs are based on the total charge weight, i.e., the weight of the booster in equivalent pounds of primary explosive weight has been added to the weight of the primary explosive.

TNT equivalency calculations were made for all of the test results. TNT equivalency is defined as the ratio of charge weights (i.e., TNT weight divided by test material weight) that will give the same peak pressure (or positive impulse) at the same radial distance from the charge. The weight of the booster, in an equivalent material weight measure, is included in the total charge weight during the computational procedure.

A companion document[1] to this report includes basic supportive data used to obtain the results presented herein. It contains the raw test data, a computer printout of the TNT equivalencies based on individual data points, and field data sheets which give test descriptions and evaluations of each test after it was shot.

3.2 Lead Styphnate

The tests conducted with lead styphnate are presented in Table 1. Test LS-11 did not ignite with a 13 gm PBX booster, 1.4 percent by weight. A 3.0 percent by weight booster did ignite 2.0 lb dry LS charges. No discernable difference in blast output was noted between the 27 and 54 gm boostering of the 1.57 lb wet shots. One 150 lb wet test did not ignite when the booster was placed on the outside of a charge bag.

The blast results for peak pressure as a function of scaled distance are shown in Figure 9. The curves shown are eye-fits to the average of the data points, except the 150 lb tests. The two 150 lb tests that did ignite did not yield the same blast output.

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[1]"Supportive Data for Determining the Blast Parameters of Lead Styphnate, Lead Azide, and Tetracene", IITRI Report J6317-J6342-1a.

Table 1. LEAD STYPHNATE TESTS

Test	Test Material Dry/Wet	Test Setup	Dry Weight (lbs)	Booster Size (gm PBX)	Booster Wt / Charge Wt (percent)	Comments
LS-11	Dry	Beaker	2.00	13	1.4	LS did not ignite
LS-9	Dry	Beaker	2.00	27	3.0	Detonated
LS-10	Dry	Beaker	2.00	27	3.0	Detonated
LS-12	Dry	Beaker	2.00	27	3.0	Detonated
LS-1	Wet	Beaker	1.57	27	3.8	Detonated
LS-3	Wet	Beaker	1.57	27	3.8	Detonated
LS-4	Wet	Beaker	1.57	27	3.8	Detonated
LS-2	Wet	Beaker	1.57	54	7.6	Detonated
LS-5	Wet	Bag	24.73	81	0.7	Detonated
LS-6	Wet	Bag	23.94	81	0.7	Detonated
LS-7	Wet	Bag	27.28	81	0.6	Detonated
LS-8	Wet	Bag	27.28	81	0.6	Detonated
B-LS-1	Wet	Shipping Drum	150	5 lb C4 cone	3.3	Incomplete Ignition
B-LS-2	Wet	Shipping Drum	150	5 lb C4 cube	3.3	Detonated
B-LS-3	Wet	Shipping Drum	148	5 lb C4 cube	3.4	Detonated

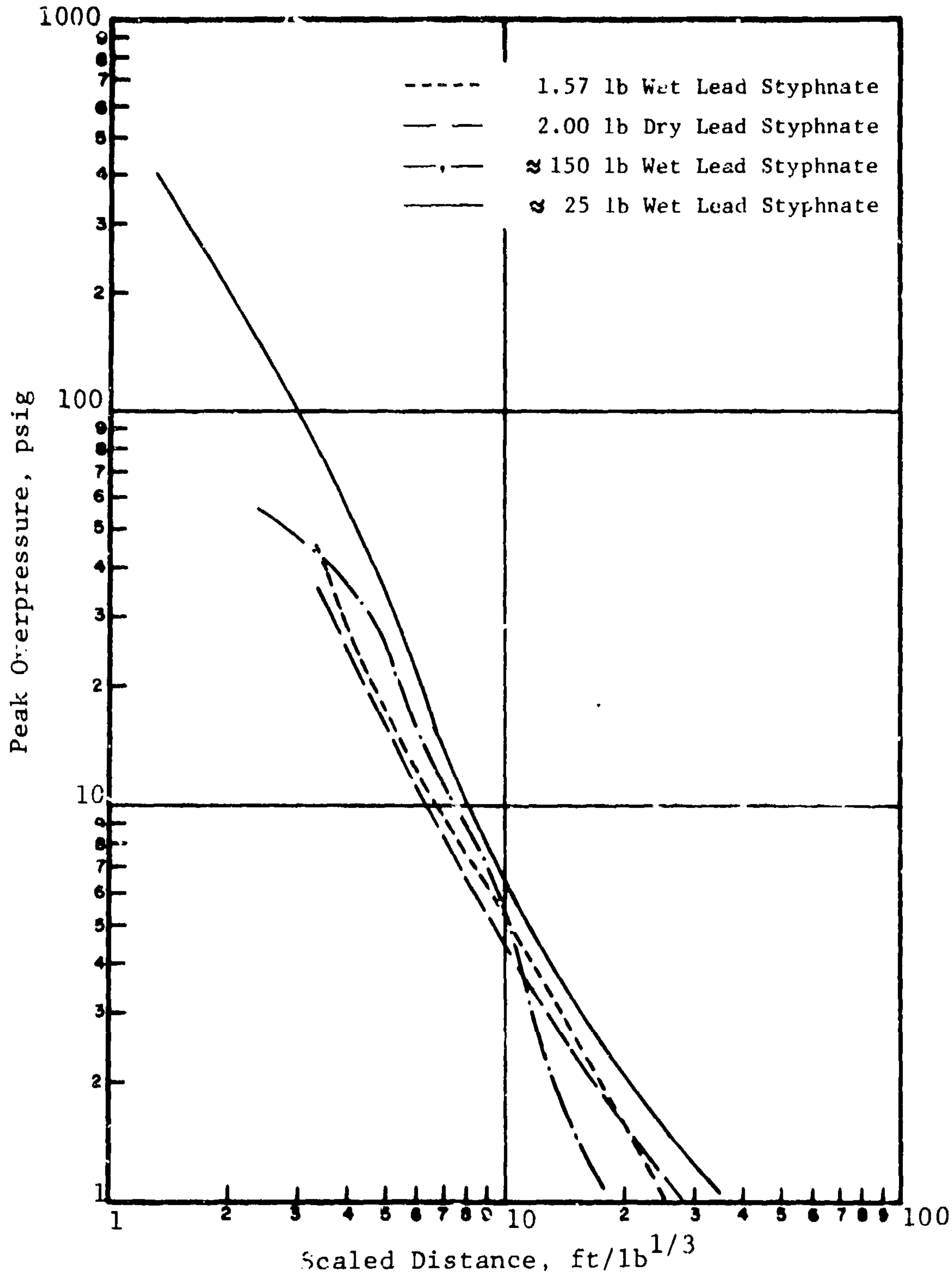

Figure 9 PEAK PRESSURE - LEAD STYPHNATE

One explanation for the difference in blast output is that a booster was placed in only one of the small bags and sympathetic detonation or propagation to detonations between bags was poor as evidenced from the first 150 lb test. The random placement of the small bags in the steel drum could have been different in these two tests. The ethanol/water mix, the sawdust, and the material of the small bags could also have acted to suppress the ignition of adjacent bags of lead styphnate. The curve shown for the 150 lb charge is an eye-fit to the maximum envelope of data points.

The greatest scaled blast output occurred in tests with 25 lb of wet LS charges. The pressure and scaled impulse, Figure 10, is significantly larger for the 25 lb shots in all scaled distance ranges tested.

The TNT equivalency, both for pressure and impulse, is greatest for the 25 lb wet LS charges, Figure 11. TNT equivalencies were computed from the pressure and scaled impulse curves shown on Figures 9 and 10. The TNT equivalency for pressure reaches a maximum at a scaled distance of approximately 5 ft/lb$^{1/3}$. Impulse TNT equivalency reaches a maximum at approximately 4 ft/lb$^{1/3}$.

When selecting an equivalency for design purposes the maximum should be determined from the worst case charge weight in the area.

3.3 Lead Azide

All of the tests conducted with lead azide (LA) are summarized in Table 2. LA was the most sensitive of the three primary explosives tested, i.e., a 13 gm booster, representing 1.9 percent of charge weight was placed under the charge and sufficed to detonate 48 lb of wet material. However, the majority of the tests were carried out with a 27 gm or larger booster. The booster size was generally 4 percent or less of the total charge weight.

The results of the tests on both wet and dry LA are shown in Figure 12 for peak pressure and Figure 13 for scaled positive impulse versus scaled distance. The curves represent the best eye-fit average to the data.

The small (1.48 lb) wet charges produced the lowest overpressure and scaled impulse of the three types of samples tested. The pressure records from these tests, 1.48 lb wet, showed multiple shock waves (or multiple peaks), indicating a nonuniform detonation reaction. Multiple shock waves were not observed in the dry material or the large wet tests.

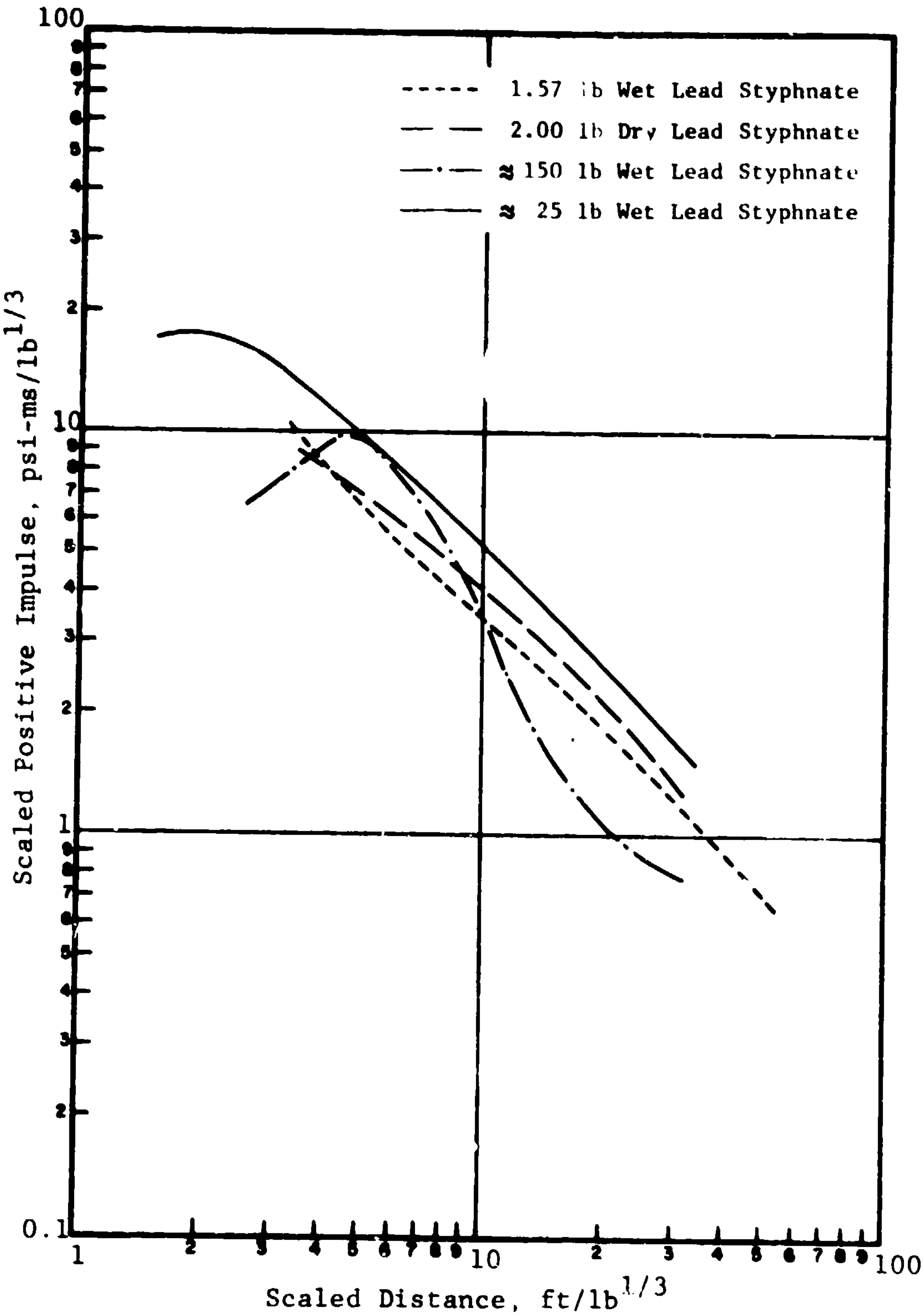

Figure 10 SCALED IMPULSE - LEAD STYPHNATE

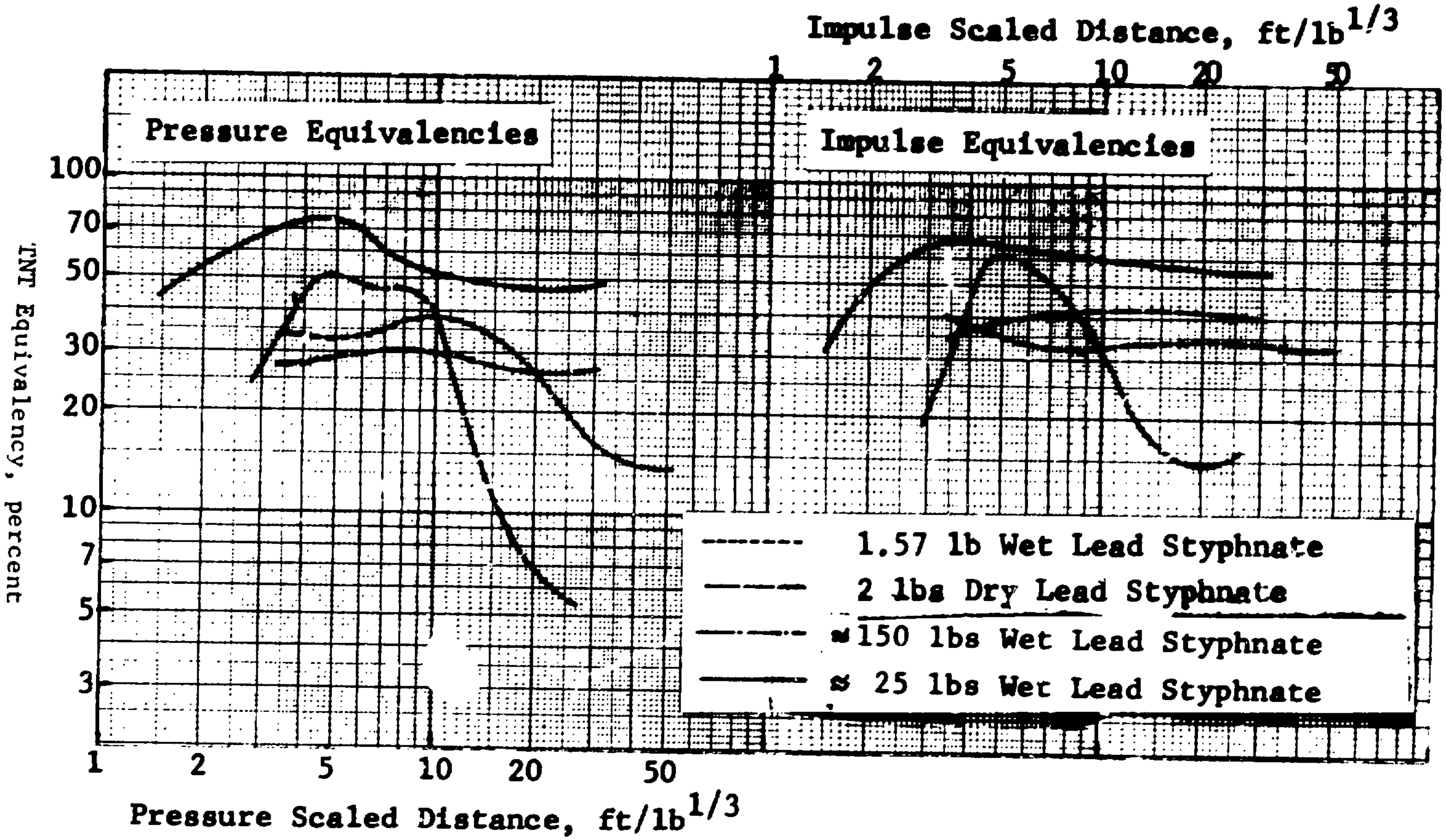

Figure 11 TNT EQUIVALENCY - LEAD STYPHNATE

Table 2. LEAD AZIDE TESTS

Test	Test Material Dry/Wet	Test Setup	Dry Weight (lbs)	Booster* Test (Size)	Booster Wt / Charge Wt (percent)	Comments
LA-9	Dry	Beaker	2.00	27	3.0	Detonated
LA-10	Dry	Beaker	2.00	27	3.0	Detonated
LA-11	Dry	Beaker	2.00	27	3.0	Detonated
LA-12	Dry	Beaker	2.00	27	3.0	Detonated
LA-3	Wet	Beaker	1.48	13	1.9	Detonated
LA-1	Wet	Beaker	1.48	27	4.0	Detonated
LA-4	Wet	Beaker	1.48	27	4.0	Detonated
LA-2	Wet	Beaker	1.48	54	8.0	Detonated
LA-5	Wet	Bag	25.65	81	0.7	Detonated
LA-6	Wet	Bag	25.10	81	0.7	Detonated
LA-7	Wet	Bag	25.84	81	0.7	Detonated
LA-8	Wet	Bag	25.10	81	0.7	Detonated
LA-13	Wet	Bag	25.10	81	0.7	Detonated

*All the boosters were PBX cylinders and they were located under the Lead Azide samples.

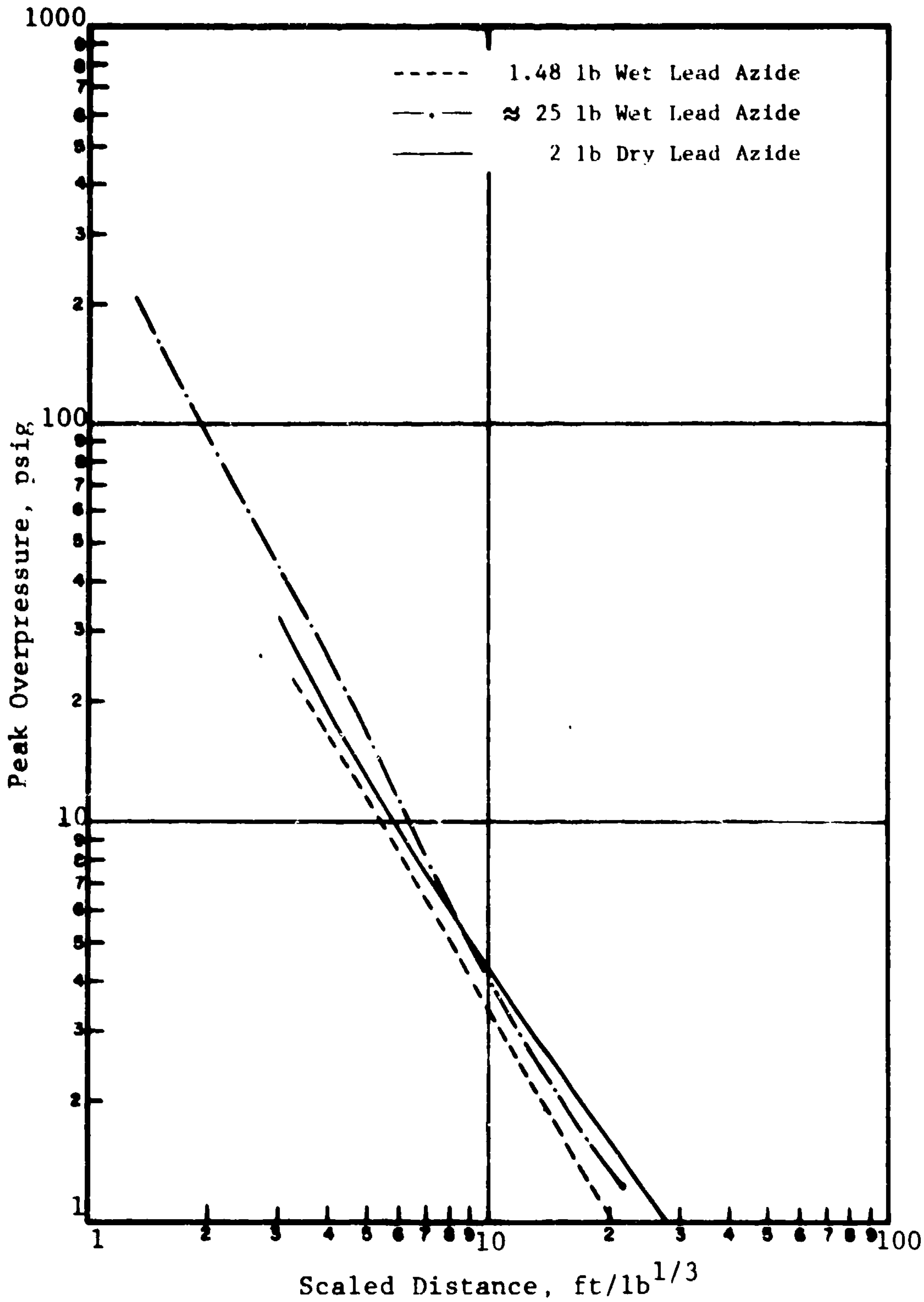

Figure 12 PEAK PRESSURE - LEAD AZIDE

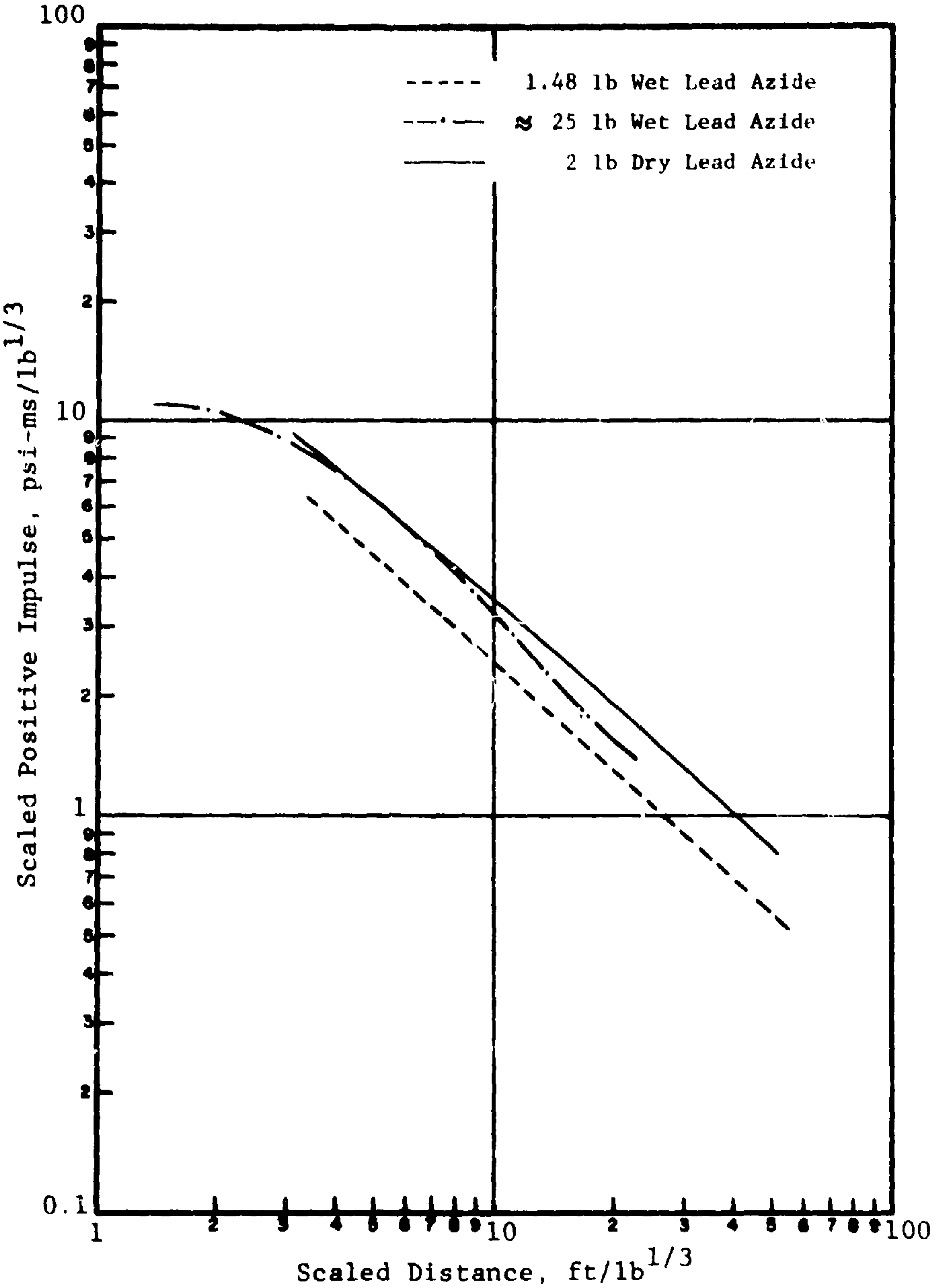

Figure 13 SCALED IMPULSE - LEAD AZIDE

The results of the tests, expressed in terms of their TNT equivalency (pressure and impulse) are shown in Figure 14. The equivalency curves were computed from the eye-fit curve for pressure or impulse for each test type.

The shapes of the TNT pressure and impulse equivalency curves are characteristic of that observed for a large number of materials whose maximum TNT equivalency is much less than 100 percent. The pressure TNT equivalency reaches a maximum at a scaled distance of about 6 $ft/lb^{1/3}$ and then decreases with distance (Figure 13). The fact that the impulse equivalency curve tends to be flatter than the pressure equivalency curve is also a common occurrence for low output materials.

There does not appear to be a pattern in the results for TNT pressure equivalency, other than that the 1.48 lb wet charges had the lowest TNT equivalency. The impulse equivalency results are clear-cut, the 2.0 lb dry and the 25 lb wet charges produce the highest and approximately the same equivalencies at all scaled distances.

3.4 Tetracene

e tests conducted with tetracene are summarized in Table ' Although primary explosives, in general, are considered to be sensitive, i.e., easy to initiate, much difficulty was encountered in trying to initiate tetracene. All of the attempts, with one exception, to initiate the tetracene with the booster placed at the bottom of the charge were unsuccessful. A narrow yellow-white cloud was produced, and unburned tetracene was found in the test area. When the booster was placed on top of the charge a measurable blast output was often obtained for dry tetracene and the large wet tetracene charges.

Due to difficulties of initiation, tetracene was tested in various configurations. In Test T-1 a 27 gm PBX booster, placed under the charge, failed to detonate 0.62 lb of wet material. Likewise, the same or smaller size boosters placed on top of the small wet charges also failed to detonate them in Tests T-10,14 and 15. In Tests T-4 and 6 the booster failed to ignite.

Tests T-2 and 3 used larger size wet charges, 9.7 and 7 lb respectively, with 54 and 81 gm PBX boosters mounted under the charge. Test T-5, with the same basic setup, also failed to completely detonate the charge even though the booster size was increased to 1/2-lb of C4 explosive.

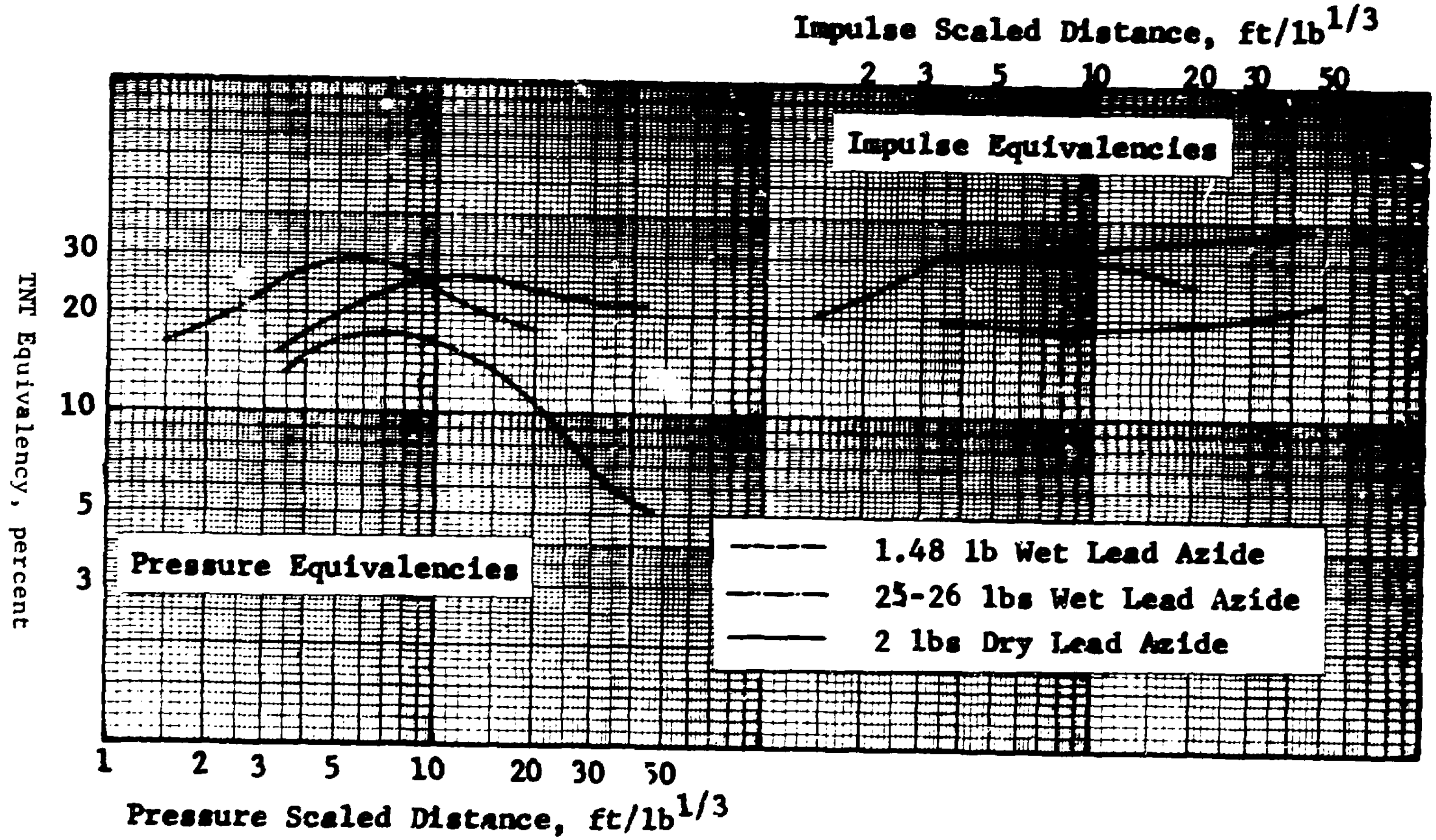

Figure 14 TNT EQUIVALENCY - LEAD AZIDE

Table 3. TETRACENE TESTS

Test	Test Material Dry/Wet	Test Setup	Dry Weight (lbs)	Booster Size	Booster Wt / Charge Wt (percent)	Booster Location*	Comments
T-4	Dry	Beaker	0.65	(gm PBX) 27	9.1	Under	PBX and Tetracene did not ignite
T-6	Dry	Beaker	0.65	27	9.1	Under	PBX and Tetracene did not ignite
T-11	Dry	Beaker	0.71	13	4.0	Top	Detonated
T-8	Dry	Beaker	0.65	27	9.1	Top	Detonated
T-9	Dry	Beaker	0.65	27	9.1	Top	Detonated
T-1	Wet	Beaker	0.62	27	9.6	Under	Consumed
T-14	Wet	Beaker	0.62	13	4.6	Top	Consumed
T-10	Wet	Beaker	0.62	27	9.6	Top	Consumed
T-15	Wet	Beaker	0.62	27	9.6	Top	Consumed
T-2	Wet	Bag	9.71	54	1.2	Under	Incomplete ignition
T-3	Wet	Bag	7.02	81	2.5	Under	Incomplete ignition
T-5	Wet	Bag	10.56	0.5 lb C4	4.7	Under	Partial detonation
T-7	Wet	Bag	9.71	0.5 lb C4	5.1	Top	Detonated
T-12	Wet	Bag in a Container	13.20	0.5 lb C4	3.8	Top	Detonated
T-13	Wet	Bag	12.40	S94 squib	---	Inside Bag	No ignition

*Indicates location of booster with respect to tetracene sample.

However, the same size booster when placed on top detonated wet charges in Tests T-7 and 12. In most cases where the tetracene did explode, the pressure record showed multiple peaks. The multiple shock waves generally coalesced at large distances. In one test, T-13, a squib placed inside the bag of wet tetracene did not even ignite the material.

The results of the tests for peak pressure and scaled positive impulse, both versus scaled distance, for wet and dry tetracene are shown graphically in Figures 15 and 16. The lines through the data represent the best eye-fit curve through the data points.

The peak overpressures obtained from the small (0.65 to 0.71 lb) dry charges were slightly higher than those obtained from the large wet charges (9.7 to 13.2 lb). The scaled positive impulse is also slightly higher for the small dry charges. Thus, it appears that the water content has a damping effect on tetracene.

The results of the tests, when expressed in terms of their TNT equivalency, are shown in Figure 17. The equivalency curves were computed from the eye-fit curve for pressure (or impulse) for each test type.

The shape of the TNT impulse equivalency versus scaled distance curve is typical of that for materials with low blast output, i.e., where the TNT equivalency is much less than 100 percent. The apparent increase in TNT pressure equivalency with distance is most likely due to the fact that multiple shock waves were produced by the explosion and the shock waves tend to coalesce with distance.

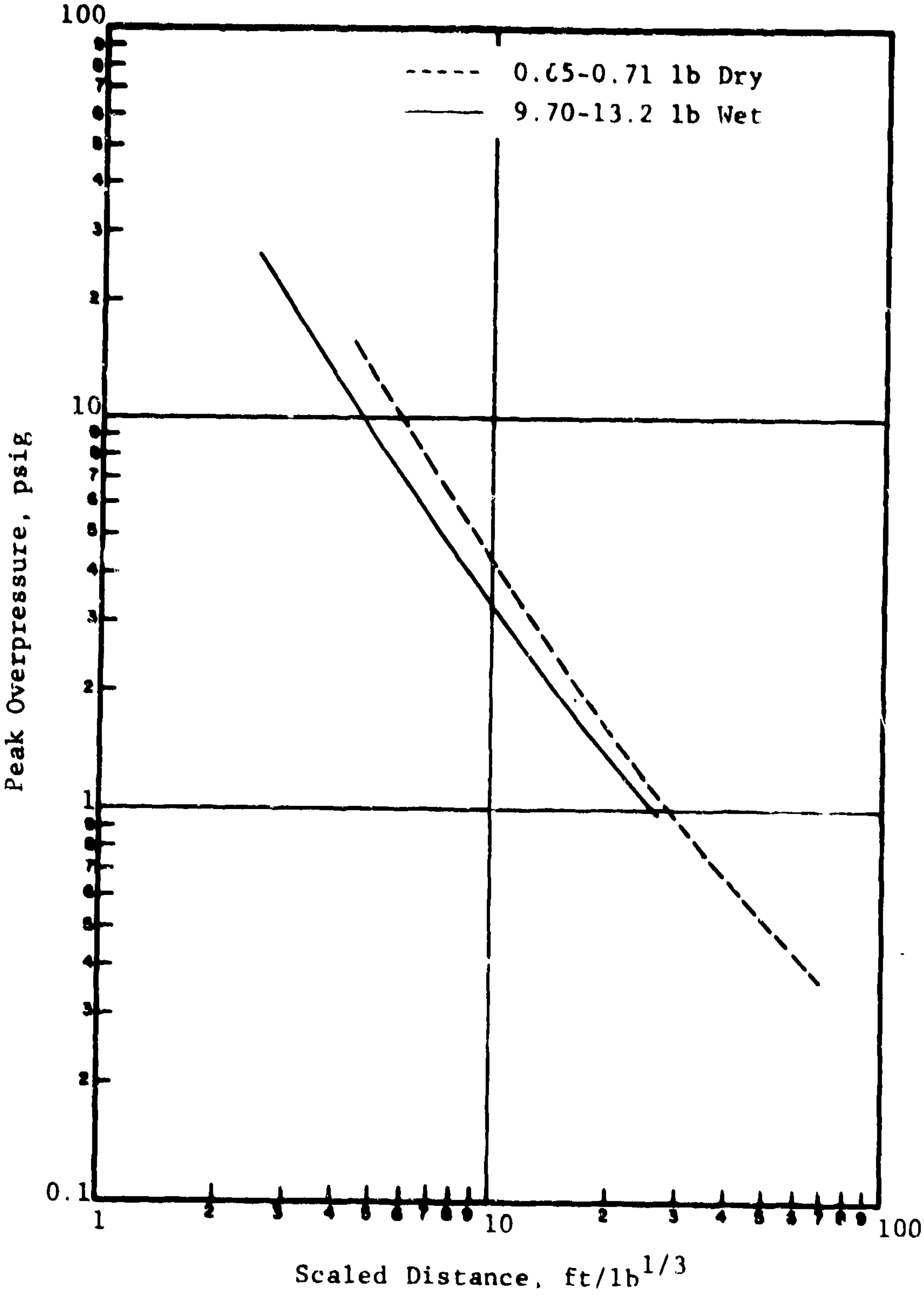

Figure 15 PEAK PRESSURE - TETRACENE

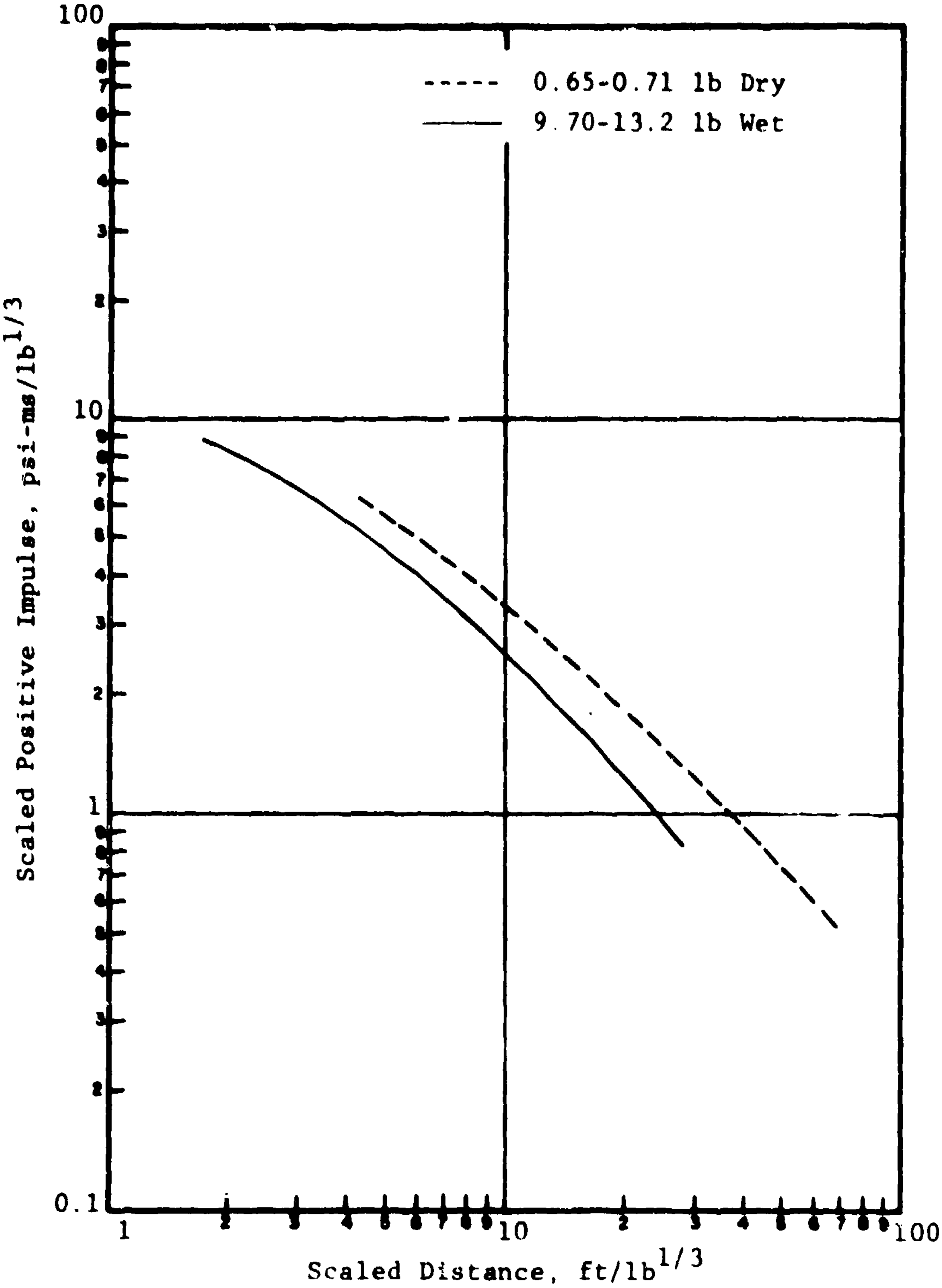

Figure 16 SCALED IMPULSE - TETRACENE

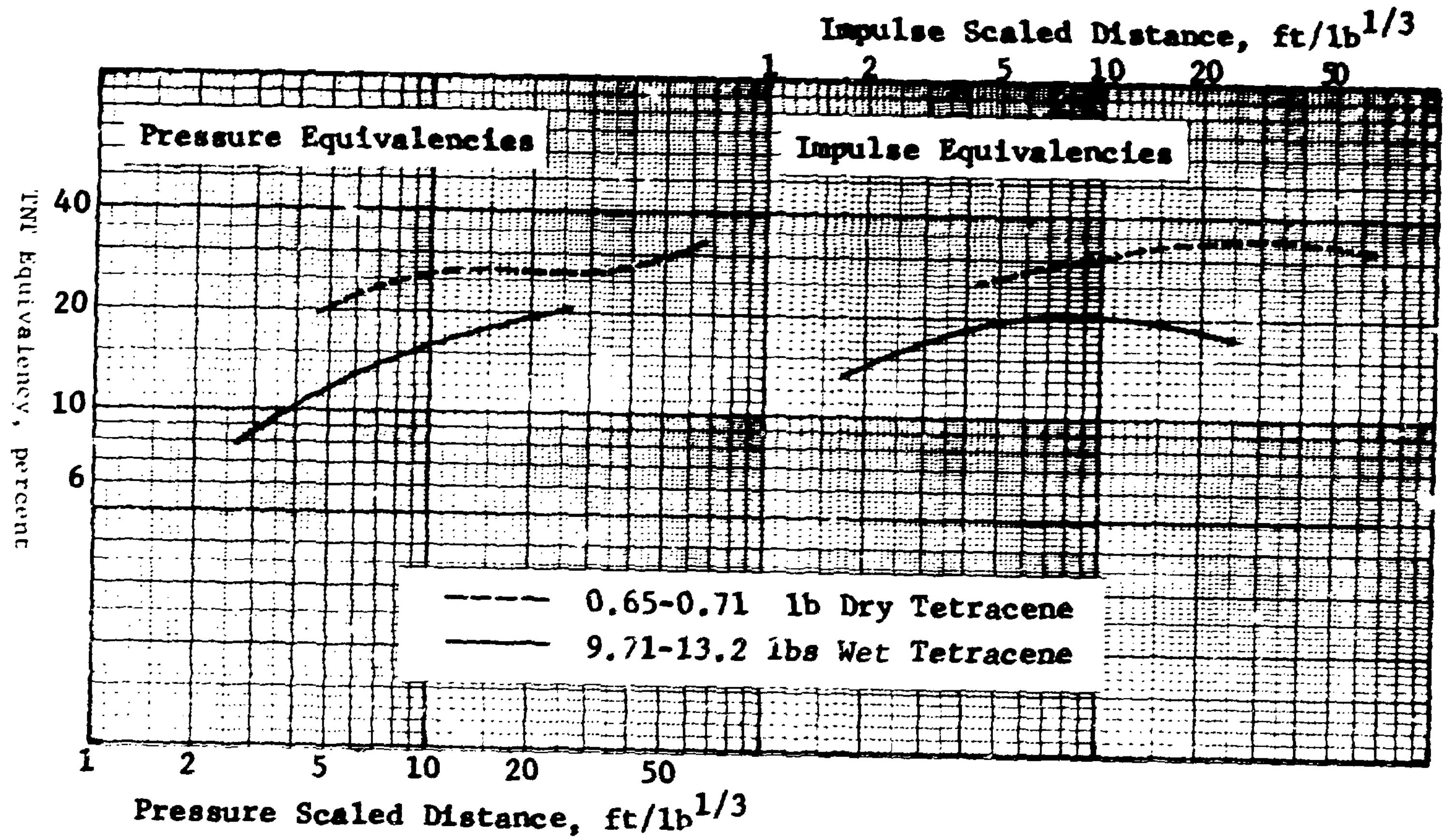

Figure 17 TNT EQUIVALENCY - TETRACENE